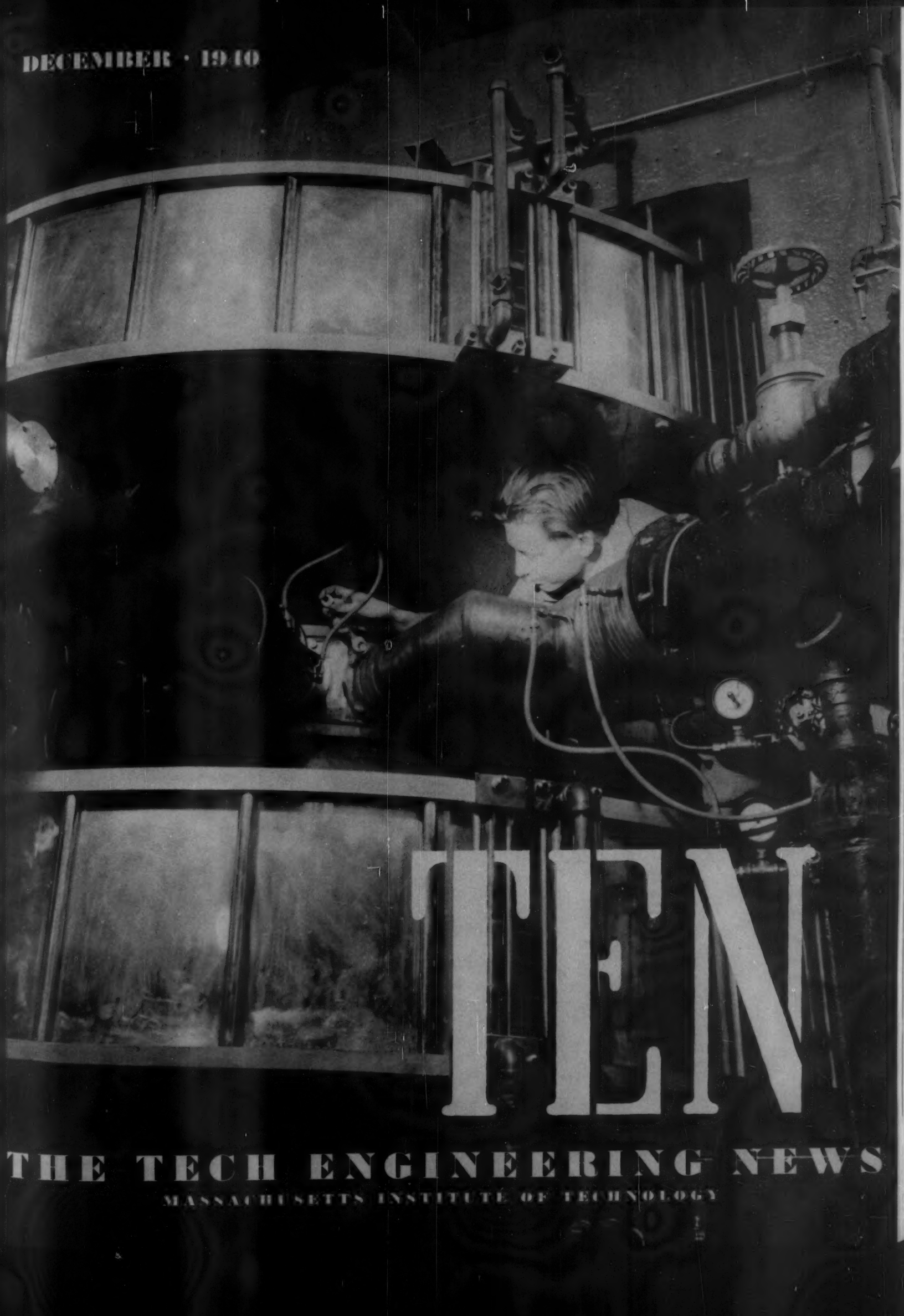
DECEMBER · 1940

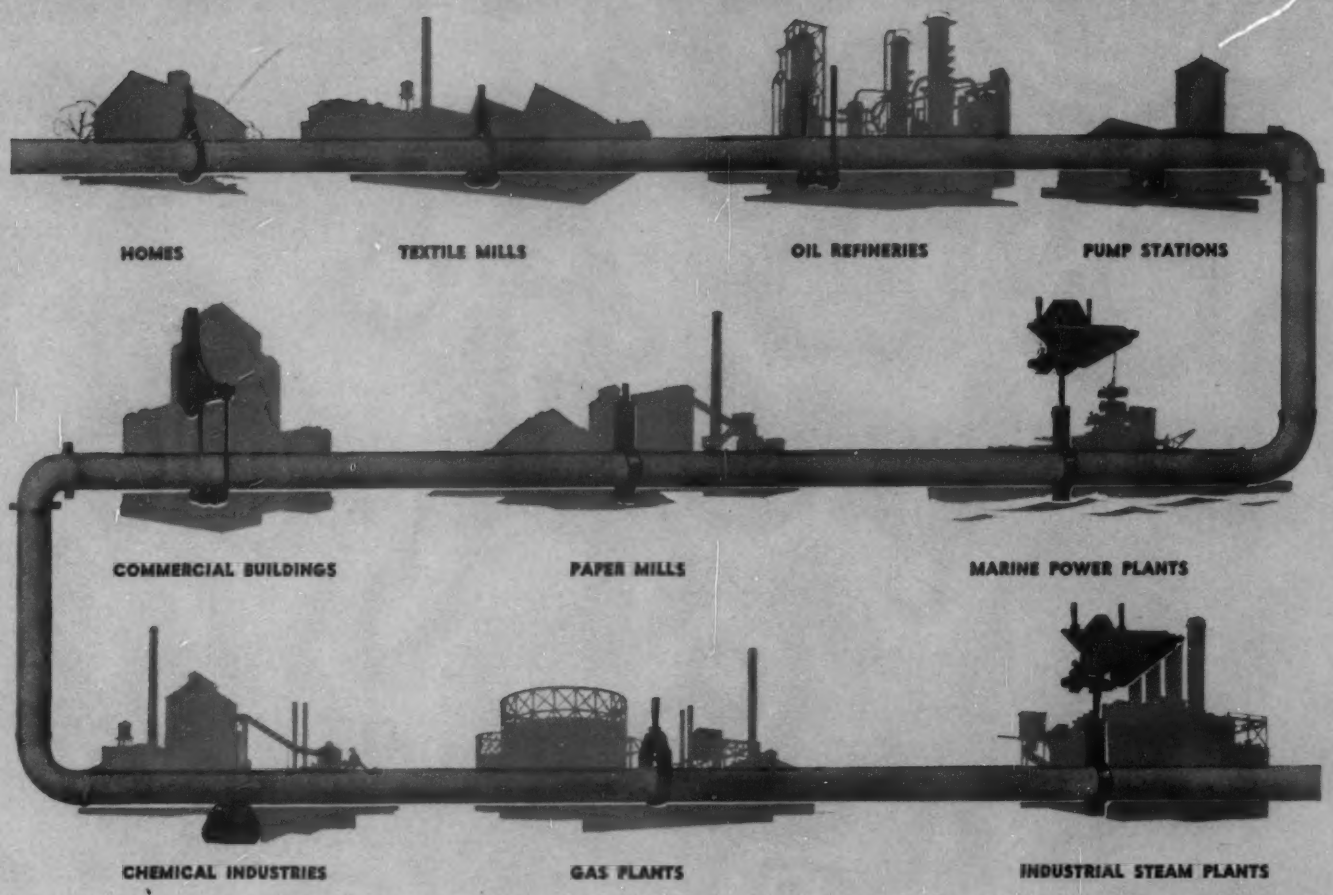


TEN

THE TECH ENGINEERING NEWS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SCIENCE IN AN UNEXPECTED ROLE...



Pipe Hangers are now *Engineered* for each specific service

NO longer is pipe hanging a haphazard matter of fastening pipes "somewhere, out of the road." Every industry has individual requirements . . . every type of system its yagaries At one extreme is the domestic water system involving chiefly dead weight. At the other, pulsing steam power lines where thermal-movement and vibration demand scientific control.

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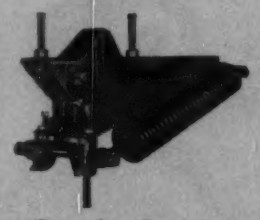
Adjustable Hangers for all low-pressure piping.



Genspring Constant-Support Hangers for power piping.

THE TECH ENGINEERING NEWS

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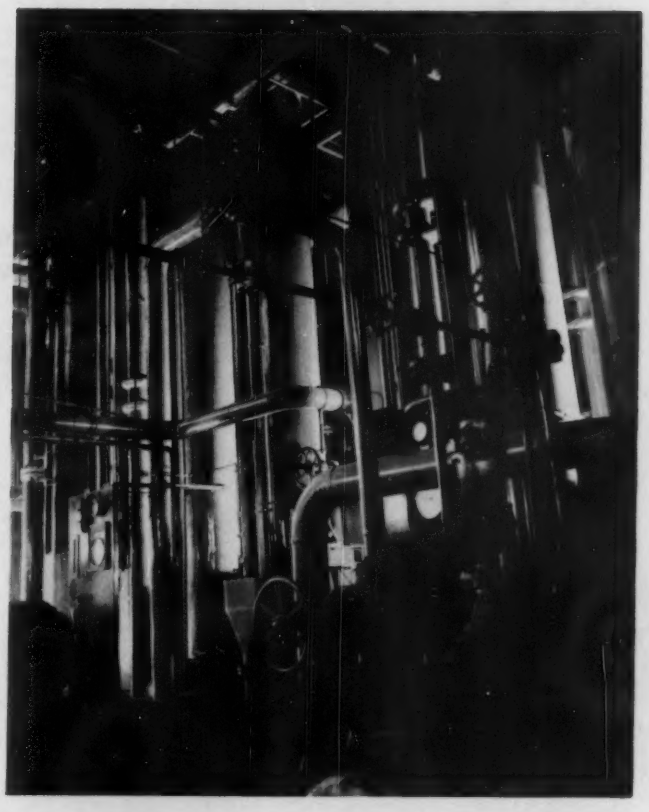

OUR COVER THIS MONTH

The back of the cyclotron viewed from below. See page 314.

VOLUME XXI
NUMBER 7

• CONTENTS •

313 DRAFT AND THE ENGINEER

As one of the few remaining democracies to what task shall we put the student engineer?

314 ATOMIC MERRY-GO-ROUND — PROF. ROBLEY D. EVANS

The M. I. T. Cyclotron moves into an important position in the field of nuclear physics.

317 ENGINEERING IN EDUCATION — PROF. ALVIN SLOANE

Skilled labor plus the basic principles of engineering yields a greater asset to industry.

319 WIND-PRODUCED VIBRATIONS — BLAKE MILLS

An invisible, uncontrollable force proves a threat to the handiworks of the engineer.

320 PULP ENGINEERING — GEORGE A. RICHTER, '13

The chemical engineer finds hidden opportunities in the wood pulp industry.

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From The Military Engineer

DRAFT AND THE ENGINEER

AS ONE OF THE FEW REMAINING DEMOCRACIES TO WHAT TASK SHALL WE PUT THE STUDENT ENGINEER?

Don't Draft the Engineer!

THE time has come for men to be practical. We are not protecting solely an ideal, as were the men of 1917; we are protecting also our own physical means of existence. Being attacked by invasion is not the remote possibility that it was in 1917; if such an event is not imminent, it is at least to be feared. And yet, only the foolishly optimistic person can look at the military condition of our country with a confident feeling. There are then two spectres in the country's nightmare; the probability that if England is crushed we will be attacked, and the obviously inferior condition of our army's material. We must put each man to the task which, when added to the sum of all accomplishments, will do the most to prevent the former or remedy the latter of these two situations.

The engineer is not unlike other men. He feels no less loyal to his country and he is willing to serve in that capacity which will help to provide the quickest, most efficient solution to these two problems. Drafted into the army service, the engineer will find that his output efficiency will be reduced in that he will be physically and mentally subordinated. In these crucial times, when every day counts, the man that could help mould the nation's resources into new and better materials for defense will be marching at the side of those in the active service. Outside the army, he could be instrumental in aiding Britain or in bettering the condition of the Nation's resources. We cannot argue the pros and cons of aiding Britain. We can assume, however, that the British people and their navy are two bulwarks that keep us free from attack and that our most practical action is the material aid which will strengthen these defenses.

Perhaps there are those who feel that engineers removed from their duties can easily be replaced by other engineers. We should learn a lesson here from England. In the first World War England drafted her engineers, only to find that when they reached the front it became necessary to call them back for more practical duties. In this war, the second World War, she has repeated her former mistake and is even now recalling engineers in the active service to more serviceable positions. Canada, in the realization of the importance of the engineers, has taken steps to keep them in their most efficient position, exempting from active service all engineers except those who prove upon examination that they will be of greater value in the army. Perhaps the comparisons are not valid since we are not at war, but even if we are not in a state of war, surely our most practical action is the application of our resources and manpower with the same ardor and intelligence as if we were at war.

We must at all costs be practical. This is reflected in our defense organization, the mobilization plans of industry towards M Day, the near-war conditions in the munitions industries at present, and the building of our "Two-Ocean" navy. We must, therefore, not fail to be practical with our most prized possession, the knowledge of science and engineering. Let us keep the men that must apply this knowledge free to continue in their present positions in the laboratories and production lines of industry.

Draft the Engineer!

The United States today can be called the world's strongest hope for democracy, and yet there are many opinions voiced in this country which are suggestive of a way far from democratic. Any class preference which is shown in the choice of men who shall prepare to defend this country suggests that we are not truly democratic and that the ideal on which our country was founded is being pushed into the past. Engineers are citizens, and like other citizens they should learn to take up arms. As student engineers we cannot hide behind the knowledge that we have acquired. We should prepare ourselves to defend our *right* to this education as well as the education itself.

There are student engineers who consider that a year at this point in their lives could not possibly be spared if they are to "maintain their knowledge." It is surprising how unimportant one year will seem when twenty or thirty have passed. If a man "forgets" how to apply engineering skill in a year, it seems obvious that he should never have set out to be an engineer.

We should not lose sight of the fact that under the selective service system there are local boards which have the responsibility of deciding whether or not a man should be deferred because of civilian activities. These men are not, as some may believe, an unknowing, autocratic group in Washington; they are groups of our own neighbors who feel keenly the necessity for drawing the maximum of efficiency from the Nation's manpower.

United States Army Engineer Corps

It should be the intention of every engineer to enter his specialized field with something more than a vast store of scientific truths. (*Continued on page 327*)

ATOMIC MERRY-GO-ROUND

THE M. I. T. CYCLOTRON MOVES INTO AN IMPORTANT POSITION IN THE FIELD OF NUCLEAR PHYSICS

By PROF. ROBLEY D. EVANS
DEPARTMENT OF PHYSICS

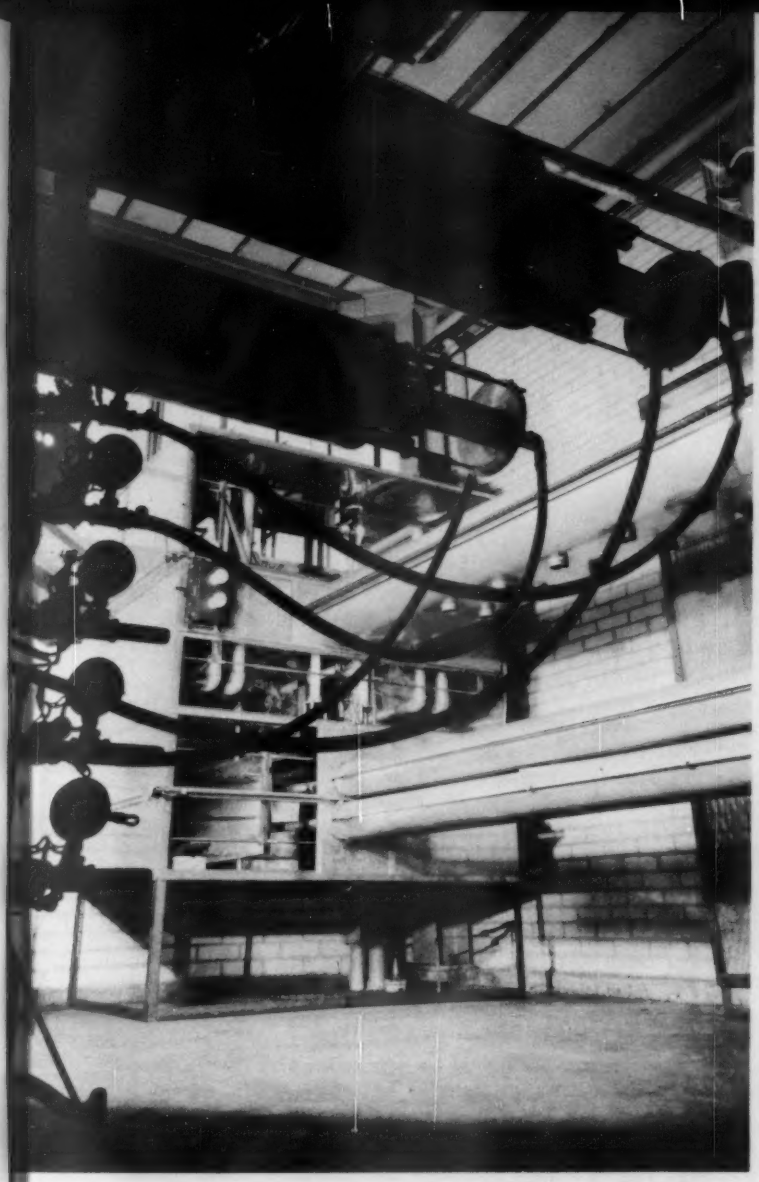
THIS is the era of coöperative research. The heyday of the individual isolated research worker is largely a thing of the past. Today teams of research workers, often representing many fields of specialization, combine their efforts in order to bring about a more rapid and a more thorough solution of current research problems. The Massachusetts Institute of Technology has long shown itself to be particularly effective in carrying out coöperative research. The Institute's staff includes outstanding experts in practically every field of science and technology. These men are accustomed to and skilled at the job of working together toward the solution of problems which are too large or too varied to be treated successfully by one branch of science alone.

The combination of the engineering approach to general problems, flanked by sound work in the basic sciences, is one of our most sound academic policies. For instance, the expanding scope of the Biology Department and the new curriculum in biological engineering is a clear step towards fusing biology, physics, chemistry, mathematics, and engineering into a single scientific unit for the attack of practical problems in human biology.

Although its discovery dates back only six years, artificial radioactivity is a new tool provided by the nuclear physicists which has already shown itself to be extremely powerful when it is applied to practical and pure problems in chemistry, metallurgy, biology, and medicine. The advances made in the last two or three years thoroughly justify the belief that artificial radioactivity will eventually be as widely used and useful a tool as the analytical balance, the X-ray, and the microscope. Primarily, the cyclotron at the Massachusetts Institute of Technology was constructed to supply a source of artificially radioactive substances to be used in coöperative research with all other fields of science, and especially those of biology and medicine. The Boston area is universally recognized as an outstanding center of investigative medical research. The staffs of the biology and medical departments of all the local universities, the staffs of our outstanding hospitals, and the nuclear physicists and chemists of both M. I. T. and Harvard are united through a number of coöperative investigations carried out jointly by various individuals in the several institutions. The significance of these coöperative studies is recognized by many of the scientific foundations. The construction and operation of the M. I. T. cyclotron was made possible by the extensive financial aid of the John and Mary R. Markle Foundation.

The cyclotron chamber, withdrawn from the magnet and with its heavy iron cover removed, showing the two hollow, dee-shaped electrodes. These electrodes are the free ends of the resonant quarter-wave lines, which bring 10 to 15 megacycle radio-frequency power from the oscillator into the dees. The ions, produced in the arc source near the center of the chamber, spiral clockwise in the central horizontal plane until they reach their maximum energy at the edge of the nearer dee. Then they are electrically drawn off this edge and out of the vacuum chamber through the port and window at the left of the chamber. Dr. M. Stanley Livingston (right), Assistant Professor of Physics, who has charge of general design and engineering of the cyclotron, discusses a detail with his colleague, Dr. John H. Buck, Instructor in Physics, who designed and engineered the interlock and remote control circuits, terminating on the panel shown on page 316.

The cyclotron is an instrument for accelerating ions, usually of deuterium, to very high velocity so that they may be used for the nuclear bombardment of other elements set up as targets. The heart of the cyclotron is a shallow, cylindrical vacuum chamber. In this chamber are two hollow D-shaped electrodes known as the dees. These dees receive alternating electric voltages from a high power radio-frequency oscillator, operating at between ten and fifteen megacycles. Near the center of the vacuum chamber, and between the dees, is a hydrogen arc discharge tube. The deuterium ions, or deuterons, are produced in this discharge and emitted from it into the center of the cyclotron chamber. They are then accelerated across the gap between the two dees by the high electrostatic potential which is put on those electrodes by the radio-frequency oscillator. After being accelerated across this gap they enter the inside of the opposite dee. They are bent into a circular path by the constant and strong magnetic field provided by the large electromagnet



Worm's-eye view of the back ends of the quarter-wave lines, and the water-cooling leads for these lines and the dees mounted on their other end. In the background, with some of the cover plates removed, is the cage which houses the 120 kilowatt radio-frequency oscillator. Running out to the right from this oscillator cage are the resonant plate and grid lines.

between whose pole pieces the cyclotron chamber is placed. The ions describe a semi-circular path inside one hollow dee, and emerge at its central edge just in time to receive another acceleration by the voltage across the dees, which has in the meantime reversed its polarity. The ions then describe a second semi-circle inside the other dee. The radius of this circle is larger than the first because the ions are speeded up each time they cross the gap between the dees. Continuing this step by step acceleration process, the ions move in larger and larger semi-circles until after about one hundred accelerations they emerge from a thin window in the wall of the vacuum chamber; then they are high speed atomic bullets. They have the same velocity and energy which they would have obtained had they been accelerated in a single discharge tube connected to an eleven million volt supply. The cyclotron is thus an instrument for producing very high velocity ions, without ever applying a comparably large voltage to the apparatus. The cyclotron takes its name from the evacuated chamber containing the dees, and in which the ions rotate, for cyclotron means literally circle tube.

Besides the vacuum chamber, the cyclotron consists of a large electromagnet and a radio-frequency oscillator which supplies the alternating voltage to the dees. This oscillator has much in common, both in power and wave length, with a large transatlantic short wave broadcasting station.

When the cyclotron is operating, the intensity of its radiation exceeds that which would be produced by all the refined radium in the world. Elaborate precautions are taken to provide shielding against this radiation. The cyclotron is operated by remote control from behind massive barriers of absorbing material.

Although a cyclotron is thought of as a physicist's machine, its design and construction involve the coöperative work of specialists from many engineering fields. Thus members of the engineering departments of the Institute collaborated in the magnet design, in the vibrational analysis of the dee system, in the design of the radio-frequency oscillator system, in the design of the power circuits with their switching and safety control mechanisms, in the design of the cyclotron laboratory building with its special foundation and service requirements, and in many other phases of the installation.

With the addition of the cyclotron and its features to the existing facilities of the Van de Graaff Electrostatic Generator, the Institute now has in operation all of the equipment needed for research in pure nuclear physics. It should be clearly understood that there is no duplication of effort nor overlapping of function between these two types of atom smashing equipment. The two installations supplement each other very perfectly and provide the Institute with all the principal facilities needed for experimental work on nuclear disintegration. The Van de Graaff Generator is ideally suited for many nuclear studies in the voltage range below 2,500,000 volts. Here it provides a very homogeneous beam of ions whose voltage can be varied easily over a wide range of values. The electrostatic generator can accelerate electrons while a cyclotron cannot. Thus the Van de Graaff Generator is being used very effectively in studies having to do with the action of high speed electrons on matter. The cyclotron, on the other hand, operates at something over four times the voltage of the Van de Graaff machine, and at very high beam current. It is, therefore, especially well adapted to the production of large quantities of artificially radioactive substances, and to studies of nuclear reactions in the higher voltage domain.

All atomic nuclei are now known to consist of an ensemble of neutrons and protons. The number of protons in each nucleus gives the atomic number of the element, for there must be just as many extra-nuclear electrons in the neutral atom as there are protons in the nucleus. Thus the number of protons in a nucleus controls all the chemical properties of the atom. Since the masses of the neutron and proton are substantially the same, the mass number or atomic weight of an atom is given by the total number of neutrons and protons in the nucleus. The isotopes of any given element differ from one another only in the number of neutrons contained in the atomic nucleus. Among all the known stable elements there are about two hundred and eighty known stable isotopes. In the last six years nuclear physicists have added to this list some three hundred and forty new nuclear species, none of which is stable. These artificially radioactive isotopes include representatives of every known stable chemical element. For example, ordinary phosphorus has an atomic nucleus containing fifteen protons and sixteen neutrons, giving a total of thirty-one particles in the nucleus and hence an atomic weight of thirty-one. By

means of several types of nuclear bombardment it is possible to produce nuclei containing fifteen protons and seventeen neutrons. These nuclei, since they all contain fifteen protons, will be chemically identical with ordinary phosphorus. Their nuclear structure cannot be the same as that of ordinary phosphorus because they contain one too many neutrons. This condition leads to a form of instability, known as artificial radioactivity. These phosphorus nuclei, containing thirty-two particles, have an average lifetime of a little over two weeks, and transform themselves spontaneously to sulphur. This transformation is accomplished by one of the neutrons, which is spontaneously converted into a proton. Thus the final nucleus contains sixteen protons and sixteen neutrons and is identical in every respect with an ordinary stable sulphur isotope. In the transition a high speed electron is produced and ejected from the nucleus. This electron or β-ray can be detected by means of a Geiger-Müller counter. Thus it is possible to detect the disintegration of each atom individually. It can be seen that this circumstance provides an analytical method which is exceptionally sensitive in detecting extremely minute quantities of chemical substances.

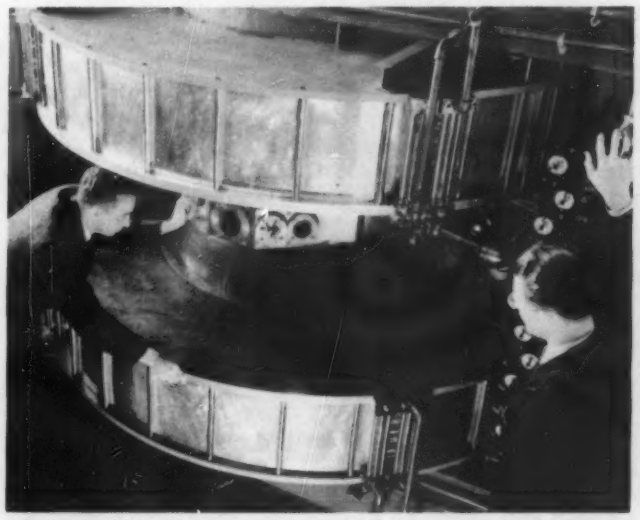
Since the radioactive form of phosphorus is identical with the ordinary type of phosphorus, the two can be mixed together, after which they will behave identically in all physical and chemical reactions. This is the basis of the so-called tracer method, or the method of radioactive indicators. It is actually better to think of this as a method of "Radioactive Spies" because the radioactive phosphorus atom does not even know itself that it is any different from an ordinary phosphorus atom, until the moment at which it disintegrates. Thus it goes along with all other phosphorus atoms through the most complicated biochemical reactions and then at the moment of its disintegration and by means of its radioactive radiation it sends a message saying, "I have landed here in this molecule or in this organ, and there are a million million other atoms of phosphorus here with me."

Since artificially radioactive isotopes of all the known stable chemical elements are now available, the domain of the new technique of radioactive spies is the reinvestigation of all problems in all fields of science and technology in which greater accuracy would be useful. Ordinarily the method has approximately a million times the sensitivity of the best microchemical methods. It also has the tremendous and unique advantage of marking individual batches of any given chemical. For example, the thyroid gland normally contains a great deal of iodine. But if a subject is given an injection of one milligram of additional iodine, containing a small amount of radioactive iodine, then the arrival of any given fraction of this injected iodine in the thyroid can be accurately determined without any interference from the overwhelmingly greater amount of iodine which was present in the gland before the experiment.

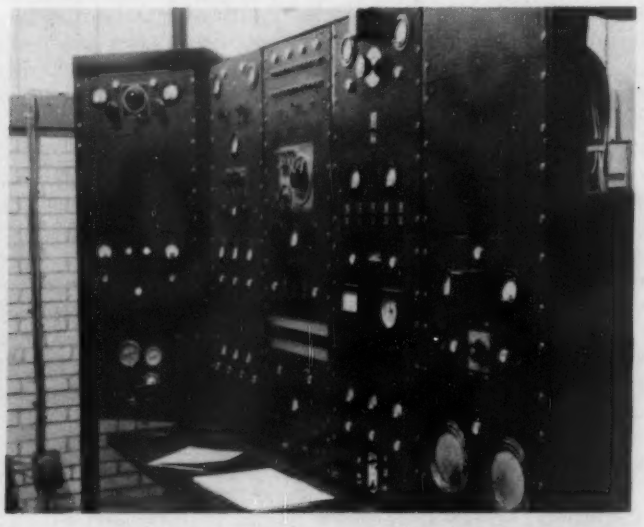
It is clear that the application of this tool requires the closest coöperation between nuclear physicists and workers in other fields to which the method is to be applied. The best results are invariably obtained by a team of specialized collaborators, each of whom is completely responsible for the accuracy of his phase of the experiment.

A number of individual problems in biology, medicine, chemistry, metallurgy, and other fields are now under joint investigation, in which members of our Physics Department are collaborating. The largest of these is a study, begun more than two years ago, of the role of iodine in both normal and hyperplastic thyroid glands. These investigations involve a coöperating team of more than eight workers from Technology's Physics Department, the Massachusetts General Hospital, and the Harvard Medical School. In rabbits and humans both normal and diseased glands are found to take up iodine from the blood stream extremely rapidly. Within fifteen or twenty minutes after an injection of iodine, the thyroid gland substantially completes its collection of iodine from the new iodine made available to it by the injection. The thyroid shows an enormous power to concentrate and utilize iodine and rapidly accumulates concentrations of twenty to two hundred times the concentration taken by any other tissue. The exact relative concentration depends upon the functional state of the thyroid gland, hyperplastic thyroids being (*Continued on page 326*)

The front face of the cyclotron viewed from above. Professor Livingston (left) checks the adjustment of the exit window through which the high energy ions emerge, while Professor Evans prepares to open the main water-cooling valve, some of whose branch lines and electric alarm gauges can be seen at the right.



The remote control panel, from which are carried out all the regular operations of starting, adjusting, and operating the cyclotron. Automatic interlock circuits and visible and audible alarms provide complete protection for the equipment and its operators. Instant two-way voice communication with all parts of the cyclotron building, and with the related offices and laboratories in the Physics Department, is provided on the lower right hand panel.



Mill and Factory

ENGINEERING IN EDUCATION

SKILLED LABOR PLUS THE BASIC PRINCIPLES OF ENGINEERING YIELDS A GREATER ASSET TO INDUSTRY

By PROF. ALVIN SLOANE
DEPARTMENT OF MECHANICAL ENGINEERING

THE power of a proverb is impaired when, overworked and abused, it becomes hackneyed. "It's an ill wind that blows no one good" is one of the run-of-the-mill variety, enjoys no special endurance properties, and has often cracked under fatigue.

The extreme exponent of the philosophy of Pollyanna or the ultimate degree of eccentricity is probably exemplified in the individual who, in the blast of a hurricane, speculates upon the good which may ensue as a corollary activity of the big wind.

We now witness the impact of a colossal program of national defense upon an unprepared populace. Immediate reactions of penetrating, introspective study reveal deficiencies and shortcomings. We find ourselves plagued with shortages of skilled craftsmen and anticipate increased difficulty in implementing our industry with all ranks of trained personnel as the tempo of the program is accelerated. In the grand manner which originated in Hollywood and has become a national disease, we may project wholesale, gigantic, colossal fantasies of education in the guise of training schools for industrial personnel, and we may reap as our reward large numbers of robots trained to properly push the button which starts Automatic Lathe No. 734.

There is no doubt that the urgency of the immediate production problem must take precedence in training programs. There is no doubt that this world is beset by hurricane, but there may be some directions in which we may find opportunity of deflecting evil influences, and reaping benefit.

Addle-pated zealots, advocates of an Utopian technocracy — a social and economic system so planned and administered that technological knowledge may be fully utilized — have served only to bring ridicule upon themselves, and to defeat saner measures to integrate the advance of technology into our social order. If our emergency programs serve only to produce pseudo-artisans, they, too, will have failed dismally.

The light which has been cast upon the lack of skilled craftsmen reveals a shortcoming in our educational system, which has failed to properly train for the crafts, aided and abetted by a social attitude which has tried to ostracize the craftsman instead of honoring him. This shortcoming is an engineering problem, for the artisans of the industrial world are the lieutenants who bring to successful fruition the schemes and dreams of the engineer. The engineer ought to actively participate in the solution of such a problem in self-interest if not for the communal weal.

An engineer has been defined as an individual who works to utilize the forces of nature for the benefit of mankind — the definition does not preclude *human* nature. The engineer, as participant in an educational program, can contribute mightily. The reasoning of engineering must never be haphazard, wandering as fancy may dictate, but logical and coherent; like the

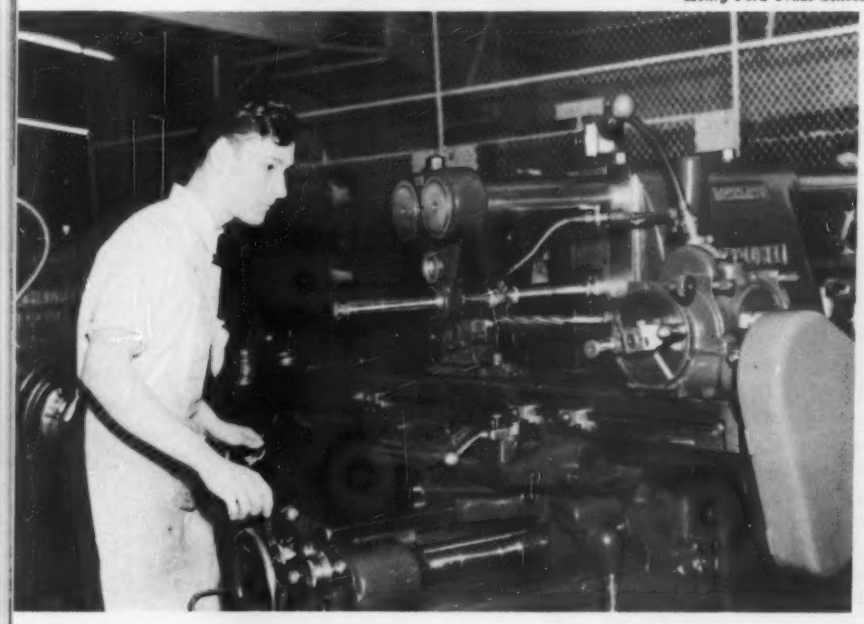
vector quantity, it must have direction as well as magnitude. Trained from his engineering infancy to isolate a free body and to account for the entire system of forces which influences the motion of the body, the engineer becomes master of a method of attack in analytical reasoning. He should be able to superimpose such method upon problems involving men as well as materials. If the engineer will fortify the artisan-training program with the same philosophy and techniques of research and ordered, constructive development from the factual findings of research which he employs, for example, in dealing with inanimate materials, that program can be immeasurably improved.

Those of us who are absent-minded enough to become college professors, and in particular engineering pedagogues, have never looked with favor upon the formal schools of education. The fads and fancies, which have frequently emanated from the professional schools of education, have deflected the engineer from accepting advances which might be fruitful. One potential avenue toward improvement is evident in the active attempts of professional schools to replace subjective groping in educational problems by objective, scientific search and research.

One of the specific gaps in our present system has been in the field of apprentice-training. The emergency program may serve toward progress in that field but not if the next gap, which is the proper training of shop foremen in production or the junior officers in the drafting and design rooms, is not closed. This is one province of education which needs engineer counsel and guidance.

Some of the larger industrial organizations of this country offer training in apprentice schools within their own frame-work. The usual training of apprentices in these schools becomes a terminal point in the formal education of the apprentice; this training could also act as a selective agency for a further extension. In a few metropolitan areas, splendid evening schools like the Lowell Institute of M. I. T. offer training to these lieutenants of the engineering world. With the exception of correspondence and extension courses, the lack of such training, however, varies directly as the distance from the metropolitan area.

". . . the artisans of the industrial world are the lieutenants who bring to successful fruition the schemes and dreams of the engineer."
Henry Ford Trade School



In meeting the challenge, engineers in the smaller industrial centers could play an active part. The rudiments of such training generally include basic evening courses in mathematics, physics, and engineering drawing, when the recruit has the equivalent of a high-school education. A continuation of such a program may introduce courses in applied mechanics, mechanism, machine and structural design, elements of electrical engineering; these subjects make for knowledge that is exceptionally applicable in local industry. Young graduates of engineering schools, who may be found in the community, are qualified to supply the teaching personnel, and are usually available since the financial return supplements a limited income. Manufacturers, Y. M. C. A.'s or other communal organizations, and school boards can furnish housing for evening classes, if results of the few efforts already made in this direction form a trustworthy indicator. Such a program can be made self-sustaining through nominal tuition fees since none of the costly laboratory equipment of the technical schools is used in the elementary classes. Guidance in the development of the curricula should be available if educators in the faculties of the engineering colleges are consulted. The student personnel is present in every industry and in every region — eager to climb the next rung of the industrial ladder.

If the engineer would participate in the education of his own lieutenants other avenues of activity are open. Another exists, for example, in the hinterlands of the educational world — in the diminutive Siwashes, operating as small colleges of the liberal arts. Many of these institutions cling tenaciously to the landscape battling for their very existence against a prospect of vanishing endowment and diminishing student body. Some could find one road to salvation in the growing demands of industry for trained personnel. Through the introduction of some pre-engineering courses, their product could be equipped to (1) enter industry as sub-lieutenants, (2) matriculate in the engineering college only after having successfully passed through one selective sieve, or (3) be deflected into other professions or vocations. The participation of the engineer here could assist in one of the most serious problems affecting the engineering college — the elimination of the unfit by pre-selection. Such a contribution would materially benefit those students who select the engineering profession as a career through the negative, though not unusual, means of eliminating other possibilities, for orientation courses could present the true picture of this profession, and weed out many of those who enter the engineering college in ignorance of what they have done. Such a pre-engineering experience would redound to the advantage of the engineering school in serving as a selective agency. Those who do pass this terminal point would matriculate in the engineering school intellectually more mature, and offer, culturally, a broader base upon which to build. The wise counsel of engineers and of engineering educators is essential in such development, and they could supply the liaison efforts necessary for successful performance.

In such directions as these, whether under the pressure of intensive preparation for a mechanized warfare or in long-range planning for a technological peacetime, the role of the engineer in education is worthy of attention. It is strange to find much present-day publication in the spheres of technological education directed at examinations of "Research *versus* Teaching." There is, rather, an active need for engineering education to make its contribution to our industrial economy through "Research *in* Teaching"— that industry may be efficiently staffed in its technical departments.

WIND-PRODUCED VIBRATIONS

AN INVISIBLE, UNCONTROLLABLE FORCE PROVES A THREAT TO THE HANDIWORKS OF THE ENGINEER

By BLAKE MILLS
DEPARTMENT OF MECHANICAL ENGINEERING

THE recognition of an aerodynamic vibration problem in the recent Tacoma Narrows Bridge failure points to the possible importance of vibration in fields where it has not hitherto been considered. The importance of aerodynamic or wind-produced vibrations in certain engineering instances has long been realized, however, and the subject has been studied at length with regard to these instances.

In everyday life, there are occasional examples of wind-produced vibration to be observed. The "singing" of telephone wires in the wind, and the tones of an "Aeolian harp", represent one type of such phenomena. Wind-operated musical instruments involve aerodynamic vibration, but the action is somewhat different from vibrations that occur in the open air. Typical engineering instances where wind-produced vibrations have shown their importance are electric transmission lines and airplane wings.

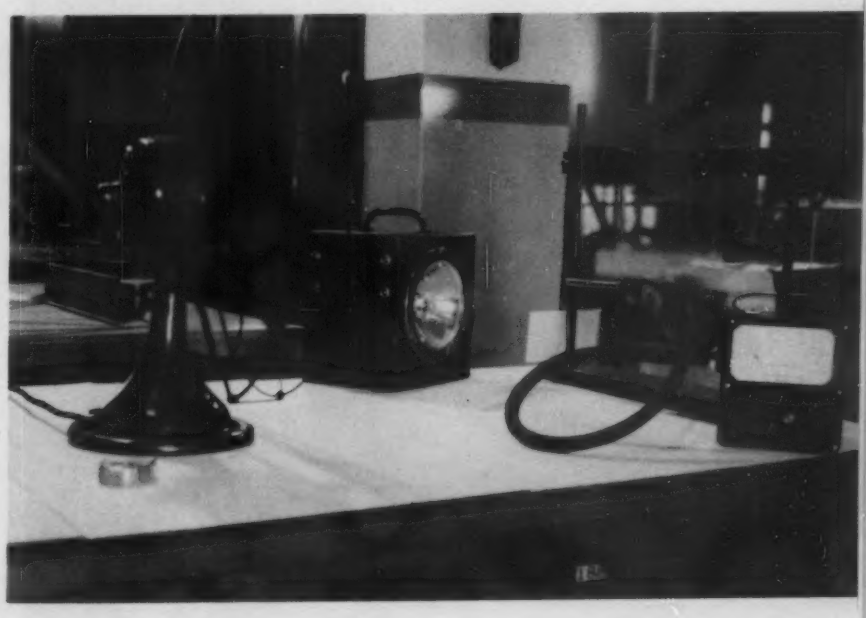
Transmission lines have been observed to undergo two entirely different types of wind-produced vibration. One of these is the violent "galloping" of an entire wire span together, with vertical motion of as much as twenty feet at the center of a five-hundred-foot span. This phenomenon is not often seen, and ordinarily requires the combination of rather high wind and sleet-covered wires. It may be prevented by keeping the wires free of sleet, with the use of occasional large electric currents in the wires. The second type of transmission line vibration is much more common, and is merely a magnified case of the common "singing" wires. The wire vibrates with an amplitude of not more than a few inches, and with much higher frequency than in the case of "galloping". Unlike "galloping", the wire span does not move as a whole, but has many nodes of zero vibration along its length. This type of vibration, at wind velocities of around five miles an hour, has frequently produced fatigue failure of wire strands. Certain types of "damping" device are often attached to the wires, near the supports, to minimize the amplitude of vibration.

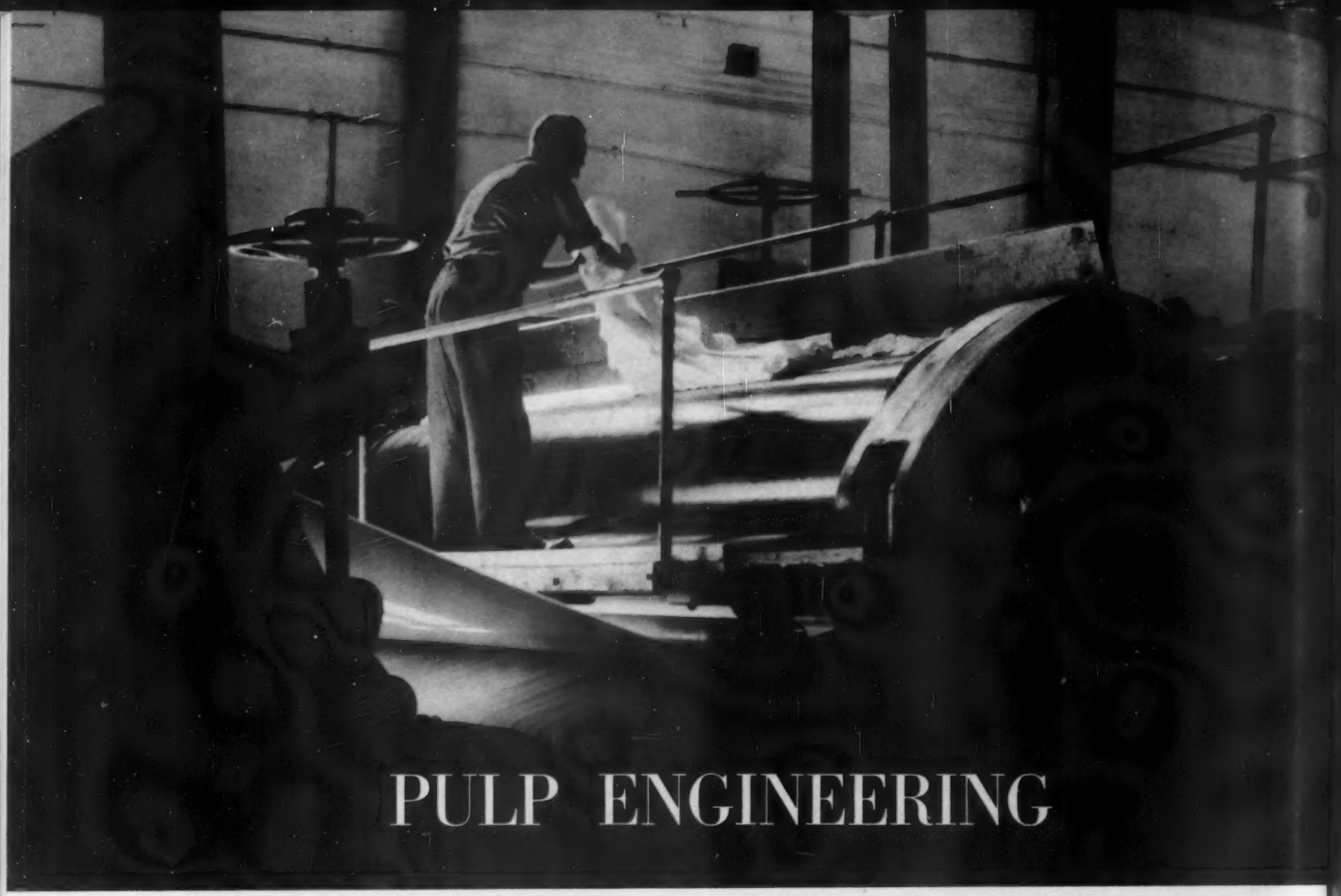
The wind-produced vibration of airplane wings and control surfaces is commonly known as "flutter". It occurs principally at high wind velocities such as encountered in power dives, and can be sufficiently violent to tear a wing off. Improved design has reduced the tendencies toward "flutter", but the solution of the problem is not yet complete.

Lengthy studies of the vibration of transmission lines and airplane wings have been made, both in the field and in the laboratory. Some of the laboratory tests have involved the use of full-size models, such as airplane wings, in wind tunnels. The Ryan Wind Tunnel at Stanford University which was built for testing transmission line spans, has a mouth fifty feet wide and two feet high, and has been used to produce low-amplitude vibration of wire spans. Full-scale tests are ideal for quantitative results, but naturally involve considerable expense. Small models can often be used to obtain reliable information, if certain rules are followed regarding similarity to the conditions of the full-size model, or prototype.

Apart from accurate small models built for obtaining quantitative information regarding their prototypes, very simple models may be used to demonstrate qualitatively some of the vibration phenomena involved. Various types of member may be supported on springs in the windstream of an electric fan, and their behavior studied. Under certain conditions, rather violent vibrations build up, while under others there is scarcely any motion at all, and the situations may be related to the practical instances of transmission lines, suspension bridges, and airplane wings. Typical experimental apparatus, shown in Fig. 1, includes an electric fan, a light member supported by small coil springs, a "velometer" to measure wind velocity, and a calibrated stroboscope for measuring vibration frequency. Shapes of vibrating member used, Fig. 2, include round, rectangular, half-round, (*Continued on page 330*)

Fig. 1. Experimental apparatus in use, including electric fan, vibrating beam, stroboscope, and wind velocity meter.





Paper stock coming over press roll of pulp drier.

THE CHEMICAL ENGINEER FINDS HIDDEN OPPORTUNITIES IN THE WOOD PULP INDUSTRY

By GEORGE A. RICHTER, '13

FEW industries offer the chemical engineer greater opportunities to practice his profession than are found in the manufacture of the wood pulps. The pulp mills abound in classic examples of what the chemical engineer designates as the unit operations. In many cases those that have been installed are practiced without the full benefit of present-day mathematical analysis, and await the attention of the trained engineer. A more careful survey will reveal additional opportunities to apply many of the basic principles upon which the chemical engineering profession is built and which will lead to the development of improved processes, to greater recovery of lost material, and to a formulation of new fiber products to supply the ever-expanding demand by the makers of paper, plastics, esters, and rayon.

In a broad sense the wood pulp industry is based on steps that comprise

(*a*) a suitable preparation of the wood,

(*b*) a chemical digestion to extract the greater part of the non-cellulose matter,

(*c*) a further purification of the raw fiber to remove objectionable residues,

(*d*) an elimination of water from the fibrous mass by mechanical means and by evaporation.

All present-day processes demand that the logs be substantially freed of bark and reduced to fragments that are not more than one inch in length with the grain and preferably less than one-quarter inch in one of the directions across the grain. The preparation of the chips is a purely mechanical operation. The choice of size and design is largely dependent upon the wood species, its density and structure, the composition of the cooking liquor, and conditions of digestion. It is evident that the rate of chemical penetration, concentration gradients, outward diffusion of spent chemical, and heat transfer into the wood units play important roles.

The choice of cooking liquor is necessarily dependent upon the type of pulp to be manufactured. The most important types are those produced with the acid sulfite and with the alkaline kraft liquors. Each procedure presents different problems and in some instances major differences in the application of the unit processes with which the chemical engineer is so familiar.

Wood Cellulose by the Acid Sulfite Process

Sulfite pulp results when the wood material is delignified by means of hot acid solutions that contain sulfites in combination with a base such as sodium, magnesium, or calcium, and a substantial percentage of free sulfurous acid. The percentage of each component has a direct influence on the yield and the quality of product. The choice of acid composition determines the ease or the difficulties which confront the chemical engineer in its preparation.

The bisulfite solution is prepared by an absorption of sulfur dioxide gases in a water solution in the presence of a suitable base material. One can burn either elemental sulfur or a pyrites base. The amount of air used in the combustion has an effect on the concentration of the gas, on the presence of sublimed sulfur, on the formation of objectionable sulfur trioxide, and indirectly on the design of the gas cooler. If pyrites are used the gases must be freed of iron oxides by precipitation, filtration or scrubbing. In any event the gases must be cooled before absorption takes place. Whether the cooling is done by direct or indirect means, the chemical engineer must calculate heat transfer and cooling surface. Rapid cooling is important to reduce the intermediate formation of trioxide. If an open cooler is used, he must study such items as character of surface material, counter current flow to assure minimum temperature of cooled gas and maximum temperature of effluent water, possible re-use of water, pressure drop of the gas through the cooling tower, and materials of construction.

The cooled gas must now be absorbed in an aqueous solution or in the presence of a water insoluble base. The dimension of the tower, the absorption surface, the application of pressure, the matter of refrigeration, as well as the chemical and physical form of the base, play important roles. A careful control of the combined sulfur dioxide is essential. The usual limestone towers have many disadvantages both in respect to the changing total surface of the carbonate exposed and because of the great size of towers needed. The adoption of a finely pulverized limestone permits a much reduced size of absorption tower and affords excellent control of combined sulfur dioxide. Cost of pulverization is a minor item.

If the liquor is to contain more than five per cent free sulfur dioxide to accomplish desired improvements in pulp quality, special means are required to prepare the primary acid. To accomplish this the chemical engineer has ample opportunity to exercise both imagination and resourcefulness. He may consider the use of oxygen-enriched air for the burners, or the design of apparatus for a low cost fortification of burner gas, or possibly the construction of a new and practical pressure absorption system.

If carbonates are employed as base material, the tail gases from the acid towers are rich in nitrogen and carbon dioxide and contain small percentages of oxygen and sulfur dioxide. With hydroxides no carbon dioxide is formed. Some thought has been given to a provision for combining the nitrogen with waste hydrogen from the cells that supply chlorine for the bleaching steps, thereby producing ammonia which is an excellent base for the bi-sulfite liquors. A quantitative study of power requirement, savings that would result because of the elimination of unnecessary liquefaction of ammonia, and the price of replaced material offer a splendid example of the application of engineering knowledge and economic analysis.

The gaseous sulfur dioxide that is relieved from the digester during a cook must be recovered and re-used. Modern plants effect this recovery without intermediate cooling by means of pressure absorption thereby bringing about a substantial saving of heat. Here again there is opportunity for the chemical engineer to effect a better recovery of both heat and chemicals and to use the strong relief gas most effectively in the last fortification of the primary acid.

The actual pulping operation as now carried out is a compromise practiced in the name of convenience. Considerable advance will be made when the several unit operations that now occur simultaneously as the digestion proceeds are segregated. Not until the cooking is achieved by a logical succession of a proper impregnation of wood chips by the combined sulfite, a subsequent penetration by the free sulfur dioxide, and an ultimate increase in temperature of the impregnated chips will best economy and optimum quality of product be realized. The solution of this problem rests upon the able approach of the chemical engineer.

When the cook is complete, the digester contents are at elevated pressure and at a temperature of about 145°C. The mass of fiber and spent liquor is blown under its own pressure from the digester into a blow pit in something less than thirty minutes. Release of pressure liberates large volumes of hot sulfur dioxide and steam. In many mills no attempt is made to recover the gas and heat. Economy is sacrificed and the community suffers. In some plants a recovery is practiced with a fair degree of success. The chemical engineer must complete the solution of the problem.

Utilization of the waste (*Continued on page 328*)

"This is the forest primeval . . ."

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EDITORIAL

PUBLIC SPEAKING AND THE ENGINEER

The importance of training in public speaking to the business executive and salesman has long been recognized by educators in those fields. During the past decade, however, it has become increasingly evident that oral training is needed by the technician, scientist, and engineer as well.

It was once thought sufficient for a technical man to know his subject thoroughly and to have others present it to the world. But such is no longer the case. Not only must the present-day engineer and scientist be able to think clearly and logically in his special field, but he must also be able to present his ideas in an understandable and convincing fashion in many different situations. In addition to this ability to present a logical oral argument, the engineer must also be able to support his conclusions extemporaneously, to literally "think on his feet".

Such abilities can only come from adequate training in public speaking. The logical place for this training to be given is in the college or school where the engineer is receiving his technical education. These conclusions have often been recognized by such associations of engineers as The Society for the Promotion of Engineering Education which concludes that "public speaking should be required of engineering students"; and generally by the alumni of engineering schools.

Here at M. I. T., training in public speaking is given to most undergraduates through the freshman English courses in which roughly one period a week for the first semester is devoted to oral work. The adequacy of this training alone, however, is open to serious question since the necessity for covering all the students in the time allowed means that little intensive aid can be given to each individual. In fact, The Society for the Promotion of Engineering Education concludes, in connection with an attempt to teach oral English in this fashion, that, ordinarily, "such activity is a profitless waste of the student's time".

Other opportunities for speech training for most students, however, do exist at Tech. They are elective courses in Public Speaking, the Stratton Prize Contests, and the Debating Society. In spite of the fact that they are all intended to fill the very gaps left by the freshman program, they too have one inadequacy. That is, in the large number of cases, because of their voluntary nature, they fail to reach the very men who need them most, those of poor speaking ability. The men who take elective public speaking courses, enter the Stratton Prize Contest, and join the Debating Society are all too often those who have had previous experience in secondary school or elsewhere and who therefore need speech training less than many others. This is especially true of the Debating Society where, in spite of the fact that it exists for the express purpose of giving as many students as possible the valuable training of intercollegiate debating, only about two per cent of the undergraduate body is active yearly. Also, the number of men participating in the Stratton Prize Contests is far below what it should be for optimum competition.

Most students have a realization of their need for speech training; but it seems that few will even take advantage of the limited opportunities available.

Henry Ford Trade School

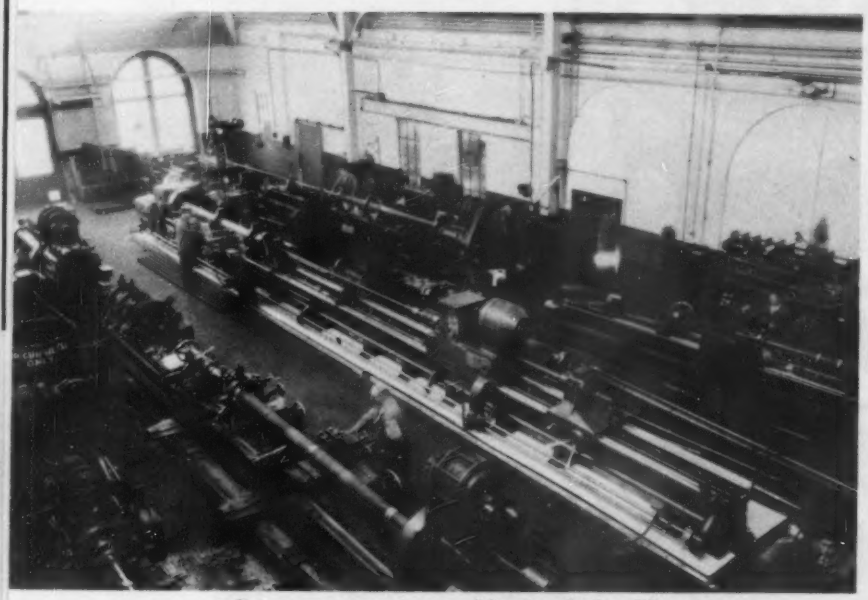
Some 21,500 cars and trucks are in regular day to day service with the Bell System. The great majority have bodies specially developed by telephone engineers. Many are equipped with power winches, air compressors and pole derricks. Each of the many types is designed to handle particular functions in the construction and maintenance of telephone plant.

Planning, purchasing and operating the world's largest fleet of commercial motor vehicles is a big job in itself.

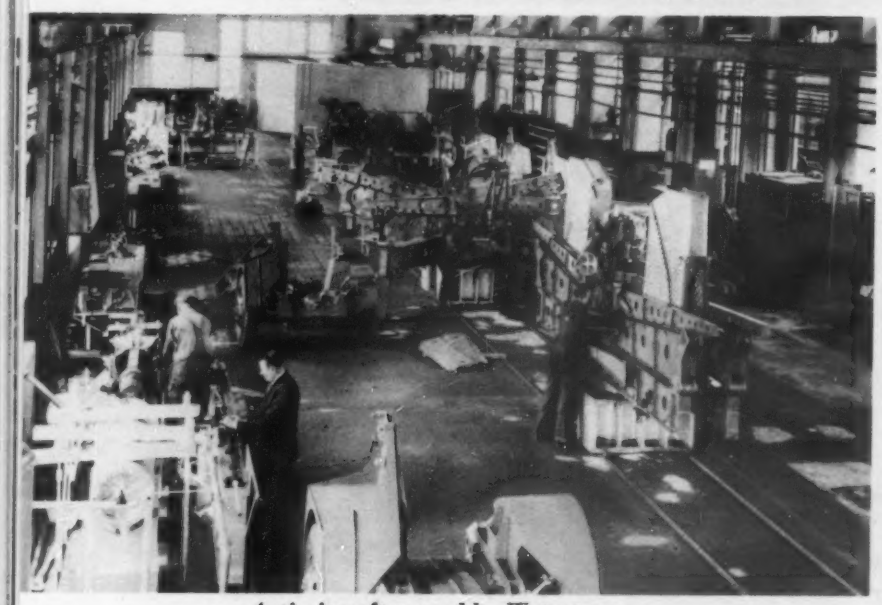
Yet it is but part of the far bigger job: providing the finest, fastest, friendliest service to the millions who daily use the telephone.

Why not give the family a ring tonight? Rates to most points are lowest after 7 P. M. any night—and all day Sunday.

Cannon shop, Watervliet. *Photos courtesy Army Ordnance*



Super gun turning and boring lathe, Watertown.



Anti-aircraft assembly, Watertown.

JUST IN CASE

• • •

WITH talk on all sides concerning Industry's part in arming America, the citizen is likely to forget that the Army itself is providing for the much-feared stormy days. We ourselves are strongly aware of the vital need for national safety; how much more concerned are those men who are assuming the responsibility for the status of the Army's equipment and thus of the Nation's strength? The increased tempo in the Army's six manufacturing arsenals emphasizes the fact that the Ordnance Department has resolved not to fall short of this responsibility.

A brief account of what is being done in each arsenal will serve to acquaint the reader with the enormous task which constantly faces the supply branch of the Army.

Frankford Arsenal — Philadelphia, Pa.

In this arsenal effort is concentrated on the manufacture of small arms, optical instruments used by the artillery, and various types of ammunition. Gages used in the construction of certain Ordnance materiel are also stored here, and much research is being done toward the improvement of sighting equipment and other fire-control apparatus.

Picatinny Arsenal — Dover, N. J.

While originally constructed as a storage depot for powder, this arsenal has expanded its operations to include powder manufacture, loading of projectiles of caliber larger than .50, and the preparation of fuses. The arsenal also houses the Ordnance Department's chemical laboratory, where experimental work on powder and explosives is now going on.

Rock Island Arsenal — Davenport, Iowa

Construction operations here include the manufacture and assembly of recoil and recuperator mechanisms, gun mounts, tanks, and automotive equipment. Machine guns and machine gun mounts are also produced at Rock Island.

Watertown Arsenal — Watertown, Mass.

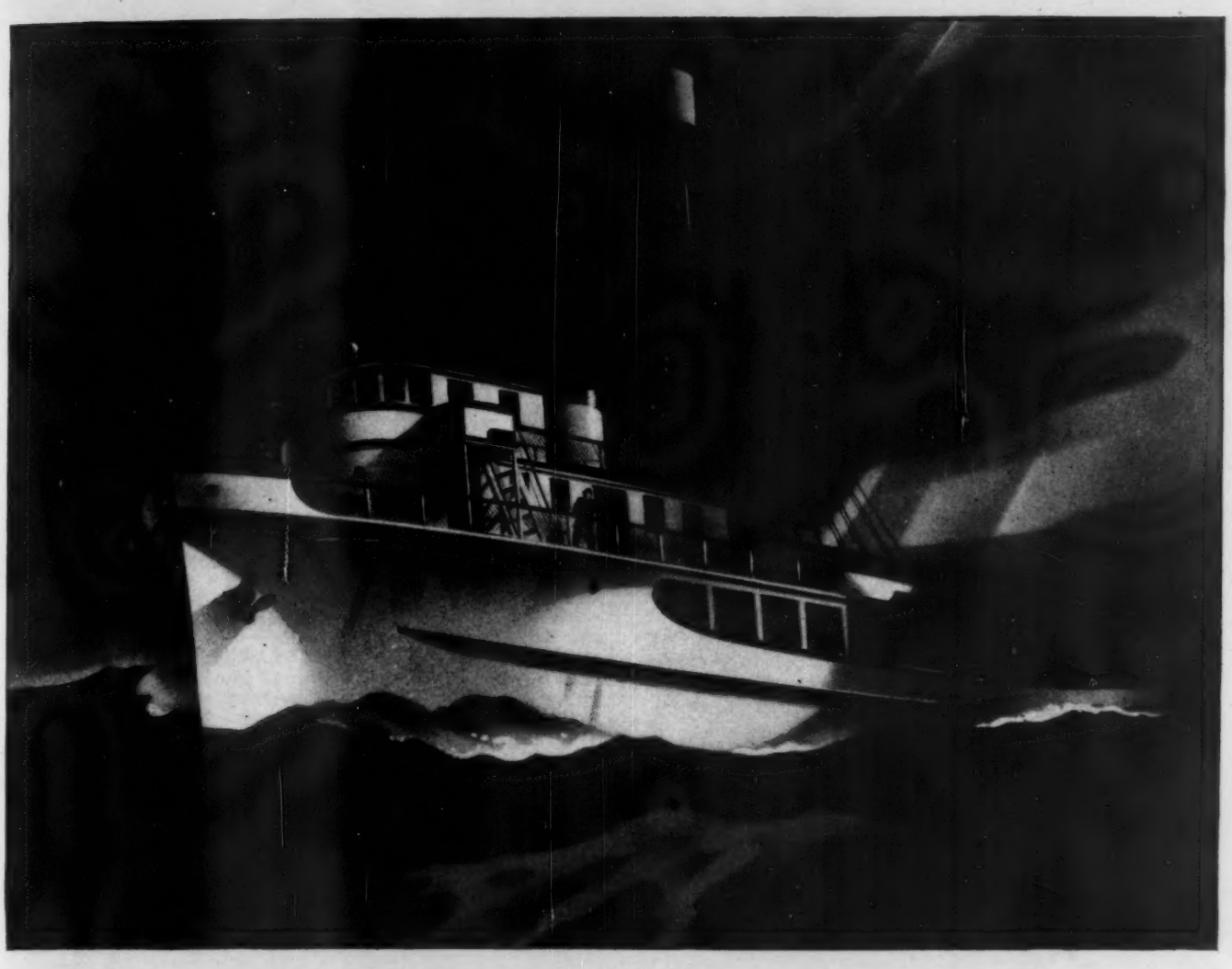
At Watertown, many of the heavier gun carriages and forgings are made for use in the construction of coastal defense, heavy mobile, and railway guns; guns of smaller caliber, such as those used for anti-aircraft defense, are actually machined and finished here. At this arsenal is located the Army's testing materials laboratory, which has facilities for metallographic research.

Watervliet Arsenal — Albany, N. Y.

The Watervliet arsenal is the Army's chief source of larger guns (those greater than 37 mm and less than 16 inches), and the guns used on the Navy's battleships are also machined and assembled here. The arsenal also serves as a storage place for tools, spare parts, and cannon forgings, which are always ready for use.

Springfield Armory — Springfield, Mass.

The oldest U. S. Armory specializes in the important manufacture of small arms and repair parts. Experimental work is being performed here in the improvement of machine guns and their construction.



4140 GOES TO SEA

It is well for all concerned that builders of marine Diesels make performance capacity the primary basis for the selection of materials. Breakdowns at sea or anywhere else are no fun for anyone, including the engine builder.

But the demand for reliability can be met and production costs still kept where they should be. One prominent builder, for example, is doing both by specifying Chromium-Molybdenum (SAE 4140) steel for a number of parts including bolts, wrist-pins, cylinder head studs, gears, tappets and crankshafts.

The fact that this steel can be treated to develop the properties necessary for applications having such different requirements is of value to both builder and user. It simplifies heat treatment and stockroom procedures. And, since simplification makes for uniform quality in the finished parts, it gives added assurance of dependability.

You will find complete data on this and other molybdenum steels in our book "Molybdenum in Steel," which will be sent free on request to all technical students interested in modern materials for modern needs.

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MOLY

ATOMIC MERRY-GO-ROUND

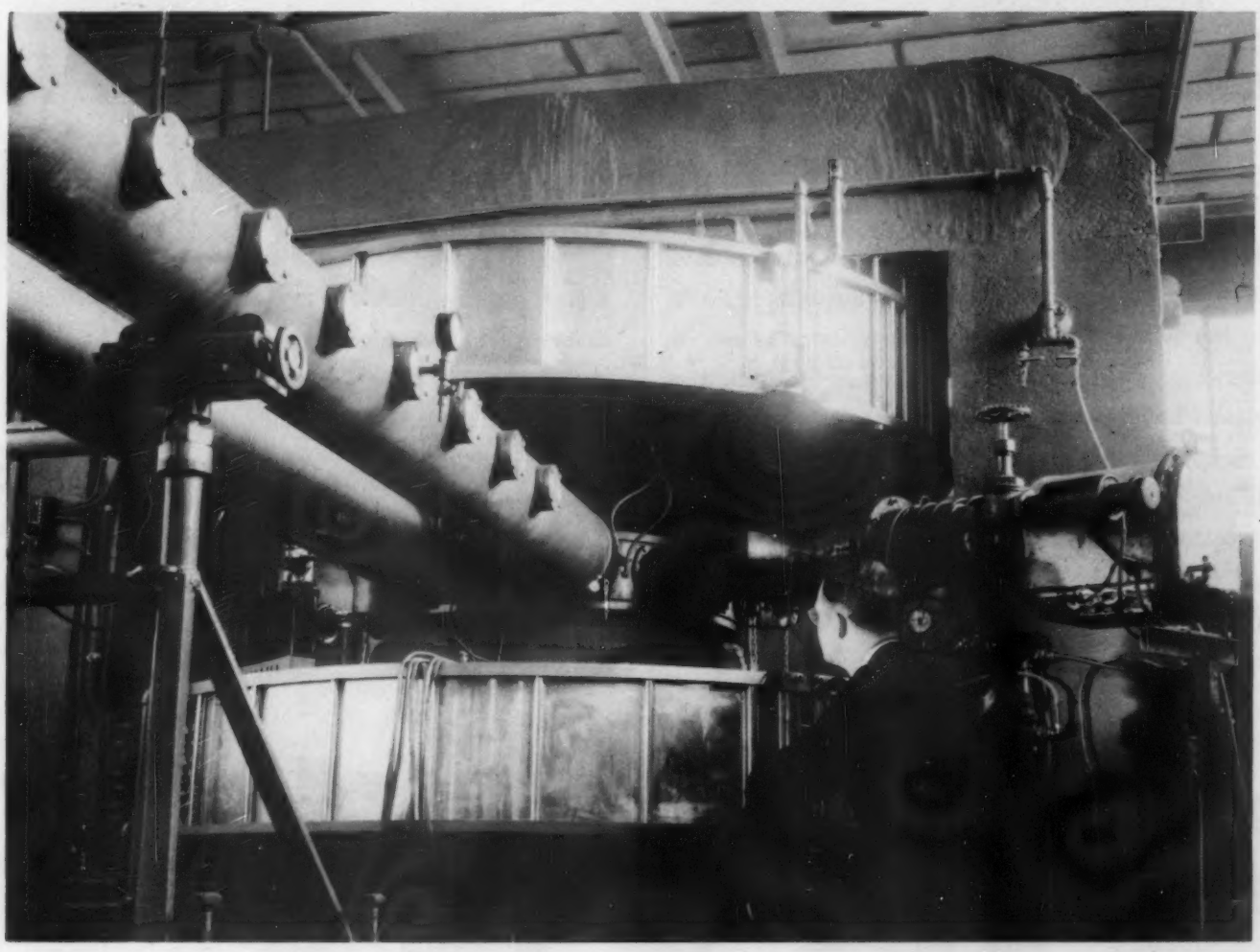
(*Continued from page 316*)

much more avid. Extensive investigations of the biochemical utilization of this iodine in the formation of the hormones of the thyroid are being carried out by this group. The experiments have already resulted in significant changes in the clinical treatment of certain forms of thyroid disease.

In various laboratories throughout the country the method of radioactive spies is being rapidly developed and applied to a wide variety of problems. Studies of the corrosion coefficient in steam boiler tubes, of the self-diffusion of metal, of the rate of chemical reaction in steel blast furnaces, and other metallurgical investigations are in progress. In entomology, studies of metabolism by insects of various substances are being thoroughly investigated for the first time, with a view to developing new insecticides, which are nontoxic to humans, and secondly to obtaining a more thorough understanding of the transmission by insects of virus diseases. The metabolism in plants, animals, and humans of all types of nutrients, toxins, vitamins, and other substances is being widely studied. In the field of chemistry, the rates and mechanisms of exchange reactions, the actions of catalysts, the vapor pressure and solubility of various substances, and other properties which cannot be measured by less sensitive means, are being measured by the radioactive spy method. By a simple dilution process it has been possible in several instances to adapt the methods of radioactive spies as a straight analytical procedure in the analysis of complicated organic compounds.

In the treatment of malignancy, X-radiation is beneficial in those cases in which the tumor is more easily destroyed than is its surrounding normal tissue. However, a number of cases exist in which the relative radiation sensitivity is unfavorable and in which X-rays cannot be used because they would destroy more healthy tissue than diseased tissue. Situations of this type occur in the case of some types of thyroid cancer. The biological action of X-rays depends upon the energetic secondary electrons, which the X-ray produces in the tissue. Any alternative method of bombarding the malignancy with energetic electrons should have identical effects. Therefore, the β-ray from radioactive substances may prove to be extremely useful in therapy, in those cases in which the tissue to be radiated is one which selectively concentrates a certain radioactive

The two large pipes leading in from the left are the outer copper jackets of the evacuated quarter-wave lines which carry radio-frequency power into the cyclotron. They terminate in the walls of the flat cylindrical cyclotron chamber. Out from the right side of the chamber come the pumping leads to the high-speed diffusion pumps, which evacuate the cyclotron chamber and the quarter-wave lines. The magnet consists of six pieces, totalling seventy tons, of Armco cast magnet iron. The pole tips are tapered to faces nine inches apart, which are plane and parallel to better than 0.001 inch over their entire 42-inch diameter. The large aluminum covered rings are the water-cooled copper coils for exciting the magnet. These alone weigh over 12 tons. Looking into the magnet, is Dr. Robley D. Evans, Associate Professor of Physics, who is in charge of the cyclotron project.



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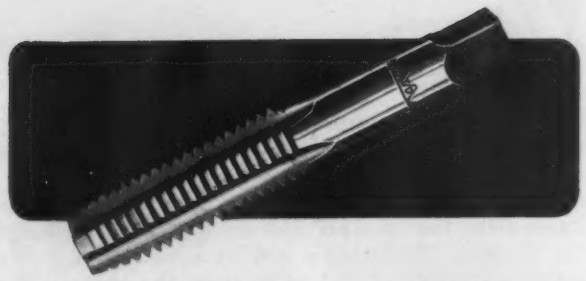

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substance. For such applications, the specific activity of the artificially radioactive substance used must be very high. Concentrations of the required strength can be produced readily with the cyclotron. The usefulness of artificially radioactive substances in therapy has already been proved in the case of leukemia, where the effects of radioactive phosphorus appear to be at least as good as the effects of X-radiation.

During the week of October 28 to November 2, 1940 a Conference on Applied Nuclear Physics was held at the Massachusetts Institute of Technology, under coöperative sponsorship with the American Institute of Physics. The week's activities were divided into separate sessions on applications to biology, chemistry, radiology, metallurgy, geology, and general sessions relating to the production and use of radioactive and stable isotopes and the protection of workers from radiation. At this Conference more than one hundred scientific papers were presented and discussed. The Conference was divided into twenty-four half-day sessions. More than six hundred scientists, from all parts of the United States and Canada, as well as a few foreign workers, attended. This Conference admirably performed its purpose of bringing together investigators who are widely separated geographically, and of providing a forum for assembling and correlating present knowledge and difficulties, and for directing attention towards fundamental lines of research which should be the subject of future investigation. There are few fields of applied science which have ever in the space of only a few years proved so effective and so universally applicable as that of Applied Nuclear Physics.

DRAFT AND THE ENGINEER

(*Continued from page 313*)

There are other equally important aspects which afford the man a well rounded background. Many of us know little or nothing about the men with whom we are now preparing to work. Many of us have been denied or have never accepted the opportunity to gain this knowledge by working in an industry. What better chance could be provided than a year of army life during which time we will be associated with men and viewpoints unlike any we have ever known before, and thereby acquire a background of understanding which will be of inestimable value in our future civilian work?

The mechanization of our Army has made details such as close-order drill factors of minor importance; emphasis is now placed on the Army's ability to move quickly and efficiently in the field, which ability includes the maintenance of mechanized equipment and materiel. Draftees with specialized knowledge will be assigned to positions where their knowledge will be of greatest benefit to the Army. Those engineers who are drafted will be able to devote to the Army a year of useful service, drawn from a limited but sufficient knowledge of engineering. The Army cannot afford to wait until the declaration of war to educate these men to its system of operation. The engineer must gain by active service *now* a conception of our Army as it really is, he must acquaint himself with his future brothers-in-arms, and he must equip himself physically to fight in a combat which seems inevitable.

PULP ENGINEERING

(*Continued from page 321*)

liquors from the sulfite process awaits a practical solution. No small outlet of a recovered by-product will solve the main problem which concerns not only the recovery for reasons of economy but the elimination of waste from the streams and rivers. It is obvious that the integration of a pulp mill by adequate recovery of sulfur, sodium and fuel value from the organic wastes would go a long way to assure the continued practice of the sulfite process. Unless such recovery be achieved in a practical manner, the sulfite cooking process is doomed. This development concerns the chemical engineer most inasmuch as it must utilize such operations as counter current washing of pulp so as to avoid unnecessary dilution of liquor, the evaporation of liquors that are acid or possibly neutralized, the combustion furnaces that may be either oxidizing or reducing depending upon the process employed, heat recovery units, handling of smelt, and the clarification of recovered liquors. If the intermediate recovery of alcohol from softwood liquors or the recovery of furfural from hardwood wastes is justified, then the chemical engineer will bring into the pulp industry the less familiar operation of distillation.

The chemical engineering aspects of the bleaching steps include mainly the study of fiber washing, the proper balance of steam and chemicals, the yield, the power expended in moving heavy concentrations of fiber, and an intelligent selection of materials of construction.

Most large wood pulp operators produce chlorine for the bleaching of the fiber. Although the design of cell and the processing of the salt have already received considerable attention, there is ample opportunity for the chemical engineer to introduce new economies in the evaporation of the by-product caustic soda, to improve present methods for the direct chlorination of the pulp fibers, and to make the bleach liquors at lower cost.

Wood Cellulose by the Alkaline Cook Process

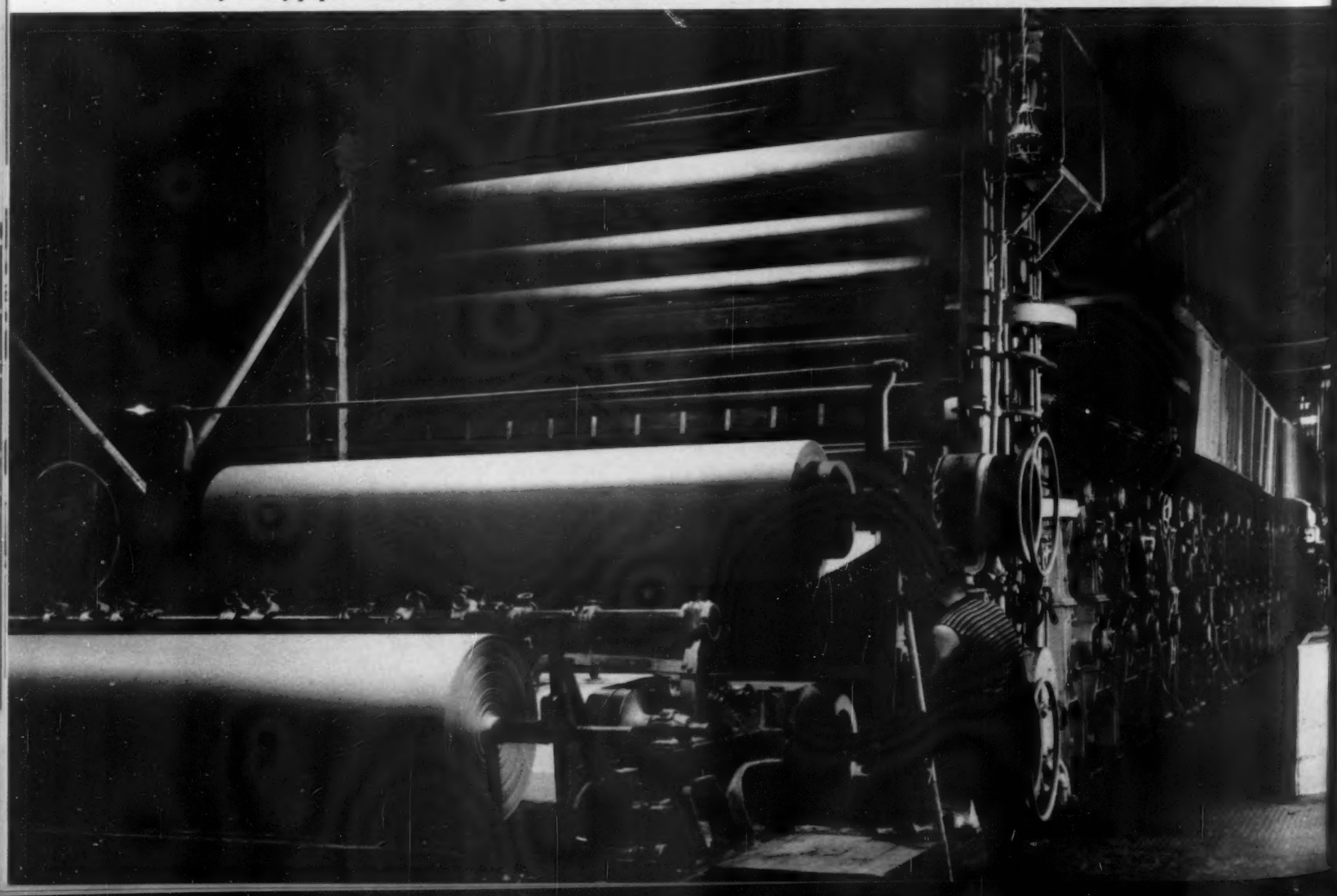
The kraft pulps are made by digesting wood chips with an alkaline liquor that contains sodium hydroxide and sodium sulfide. The spent liquor is separated from the pulp at the end of the cook, evaporated, and burned in a reducing furnace which delivers a smelt of sodium carbonate and sulfide. The carbonate is causticized with lime and together with the sulfide is returned to the cycle as active chemical. Chemical losses are made up by adding the equivalent amount of salt cake to the evaporated liquor just as it enters the furnace. Salt cake is reduced to sulfide. The carbonate is accounted for by substantial losses of sulfur oxides in the furnace gases.

Problems of corrosion are few, although the presence of accumulated chlorides that originate in the salt cake are often held accountable for corrosion that sometimes occurs in the evaporators and in the furnaces. The kraft process, as it is now practiced, has no important gas absorption problem.

High concentrations of cooking solution make recovery obligatory. Spent "black liquor" from the digesters is reclaimed either by rotary vacuum washers or by multiple counter current washers that comprise as many as eight or ten effects. In no other step of the process has the chemical engineer been more successful in attaining high efficiency.

Multiple effect evaporators (*Continued on page 333*)

Dry end of paper machine showing reel and rewinder.



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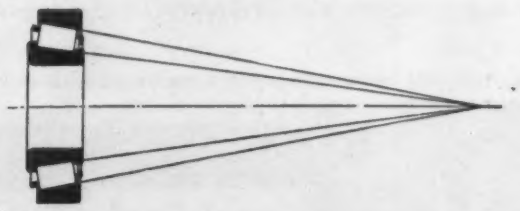

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TIMKEN
TAPERED ROLLER BEARINGS

WIND-PRODUCED VIBRATIONS

(*Continued from page 319*)

I-beam, and flat sections. Each member may be mounted on the spring supports, which were patterned after apparatus used by Prof. J. P. Den Hartog of Harvard for similar purposes.

Since the large horizontal I-beams of the Tacoma Narrows Bridge are believed to have played an important part in the vibration of the bridge, the behavior of the I-beam model will be considered first. The model is eight inches long and two and a half inches deep, made of cigar-box wood. When mounted on springs in the airstream of the fan, it built up a vertical vibration of more than an inch when the wind velocity was about nine miles per hour, and with less wind, the vibration has the same frequency but less amplitude.

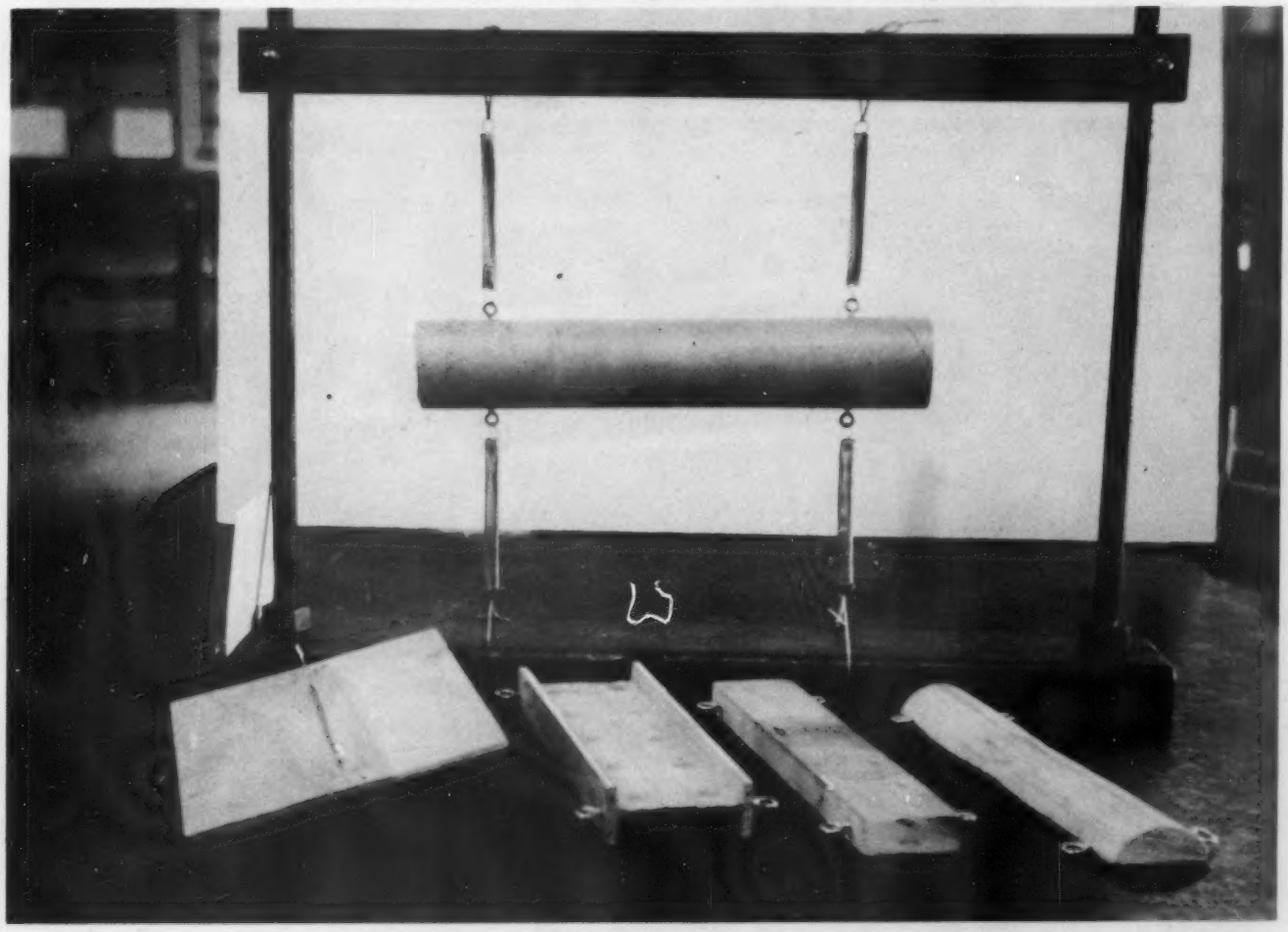
This vibration of the I-beam is the same phenomenon as the violet "galloping" of sleet-covered transmission lines, and depends upon "aerodynamic instability" of the member. This instability comes from the fact that on certain members a slightly downward wind produces a slightly upward resultant force, or "lift" (Fig. 3). If the wind is horizontal and the member is given a slight upward motion, the "effective wind" on the member becomes inclined slightly downward, and the resulting lift tends to increase the upward motion. The lift arises from a difference in wind velocities above and below the member, dependent on the shape of member. If the member is mounted on springs, it moves until the elastic forces balance the lift, which disappears when the member stops, and then the springs reverse the original motion. With the member moving downward, the lift also becomes downward, and the cycle repeats itself as a continuous vibration. This vibration requires a slight initial motion before it can build up, but the wind-eddies around the member are sufficient to produce this motion.

When a number of holes were drilled through the web of the I-beam, the vibration was only slightly reduced, although large enough holes should stabilize the beam. The attachment of a half-cyclindrical cardboard shield to the windward side of the beam almost eliminated the vibration. However, this cure should not be effective at all wind velocities, as will be discussed later. When other members were substituted for the I-beam, the rectangular section vibrated readily, as did the half-round section with its flat side to windward, but the half-round section with its round side to windward was stable.

With a ten-inch length of two-inch diameter cardboard tubing mounted on the springs, the nine-mile-per-hour wind produced almost no vibration. However, when the wind velocity was reduced to five miles per hour, a vibration of more than an inch was built up. Further wind reduction decreased the vibration again.

This behavior has a cause entirely apart from the "instability" previously discussed, and is the same phenomenon as the "singing" of telephone wires and the low-amplitude vibration of transmission lines. When wind blows transversely past a fixed cylinder, its average resultant force is in the same direction as the wind

Fig. 2. Cylindrical beam on elastic mounting, with other types of member in the foreground.



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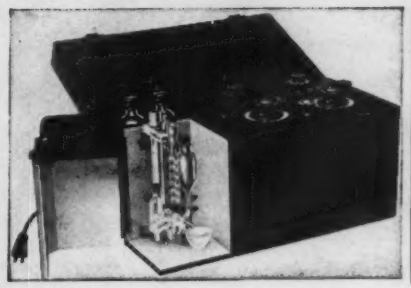

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which would seem to indicate stability. However, even a perfectly steady wind produces a force on the cylinder which is not constant, but which varies rapidly because of wind-eddies which form on the leeward side. At any section, two eddies tend to form behind the cylinder (Fig. 3), one of which builds up at the expense of the other, then tears away and allows the other to build up. This action repeats at a rate, or "eddy frequency", dependent only upon the wind velocity and the cylinder diameter. When one eddy becomes predominant, it produces a difference of wind velocities above and below the cylinder, and thereby a vertical force component. As the eddies shuttle back and forth, the vertical force reverses, and a vibration is produced if the cylinder is supported on springs. Theoretically, this sort of vibration should occur at any wind velocity, but the amplitude becomes appreciable only when the eddy frequency corresponds approximately to a natural frequency of vibration of the member on its supports.

In the tests of the I-beam and other sections, there was no appreciable vibration caused by wind-eddies, as the eddy frequencies did not correspond to the natural frequencies of the vibrating systems. Vibrations caused by unstable shapes and by wind-eddies may be readily distinguished by varying the wind velocity. An unstable member always vibrates at one of its natural frequencies, and with an amplitude which increases with the wind velocity. Wind-eddy vibration has a frequency which varies with the wind velocity, and has maximum amplitude at a wind velocity for which the eddy frequency corresponds to a natural frequency of the mechanical system. For the I-beam with shield attached, little vibration was obtained in the available range of wind velocity; however, there should be some wind velocity

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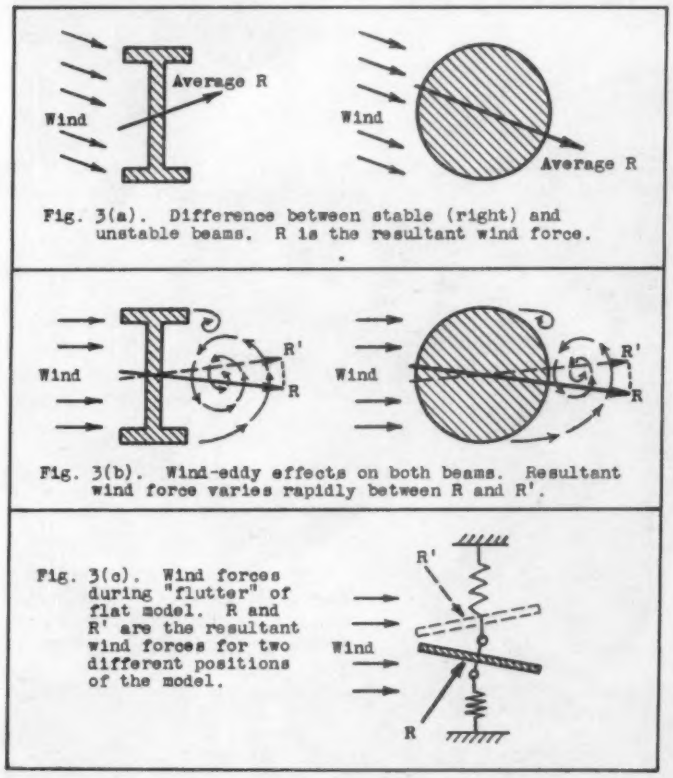
Average R
Wind
Wind
Average R
Fig. 3(a). Difference between stable (right) and unstable beams. R is the resultant wind force.
Wind
R'
R
Wind
R'
R
Fig. 3(b). Wind-eddy effects on both beams. Resultant wind force varies rapidly between R and R'.
Fig. 3(c). Wind forces during "flutter" of flat model. R and R' are the resultant wind forces for two different positions of the model.
R'
Wind
R

Fig. 3. Diagram showing various types of vibrations, their causes and effects.

which would produce very considerable vibration by the wind-eddy effect.

The "flutter" of airplane wings is a very complex phenomenon, but a closely related types of vibration may be demonstrated on a simple model. If a flat board (cigar-box lid) is mounted on the springs, the wind produces a vibratory motion which is seen to consist of two components. One is up-and-down and the other is a rocking motion. The "flutter" becomes accentuated if the board is weighted to produce almost equal natural frequencies for rocking and for up-and-down motion.

The following explanation is somewhat crude and incomplete, but may give some idea of the action. When the board is tilted slightly upward (Fig. 3), a horizontal wind causes upward motion until the spring forces become too great. Then the board stops, the springs cause the board to swing somewhat below horizontal, and the wind then forces the board down. A continuous vibration or "flutter" is thus produced. The flutter of airplane wings is much more complicated than this, and can occur in many different ways, but in general involves at least two "coupled" modes of vibration as does this model.

In conclusion, it is to be emphasized that models of the sort described are not intended to provide quantitative information applicable to engineering practice, but they serve to demonstrate in a simple manner three types of wind-produced vibration which have assumed vital importance in certain practical cases. The vibration of the Narrows Bridge appears to have involved flutter, and one or possibly both of the other types of vibration discussed.

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PULP ENGINEERING

(*Continued from page 328*)

are standard equipment. Chemical engineering will doubtless find a way to reach higher than present-day concentrations of fifty per cent thereby improving the capacity of the furnace and increasing the amount of steam produced from the liquor that accompanies one ton of pulp.

One of the largest single items of chemical cost is the lime that is required to causticize the carbonate. Quantities of six to eight hundred pounds per ton of pulp are commonplace. Solubility curves suggest the possibility of separation of sodium carbonate from the sulfide by cooling a hot saturated smelt solution or by supersaturation. The crystals of carbonate so removed can then be used to react with sulfur dioxide that now escapes the system by way of the furnace gases. The sodium sulfite so recovered can be substituted successfully as a replacement of the equivalent hydroxide in the cooking liquor. A perfect case would eliminate the causticizing step entirely. Only by clever application of chemical engineering principles can this worthy objective be realized.

As already stated, in present-day practice the smelt from the furnace is dissolved and the carbonate is causticized. The precipitated calcium carbonate can be removed by batch or continuous filtration, or by means of a continuous concentrator that settles the sludge. In either case, the problem that faces the chemical engineer is one of maximum recovery of alkali with minimum dilution of liquor, since strong liquors permit the operator to use greater quantities of unevaporated

A stand of balsam fir.

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black liquor for dilution of the active chemical prior to cooking with a consequent increase in organic content of the succeeding black liquor. A saving in evaporation results. The calcination and re-use of the moist calcium carbonate sludge is practiced only where fuel costs are less than the value of newly purchased lime, but whenever the kraft mill is adjacent to a sulfite unit the wet sludge can replace limestone that is otherwise needed.

Regardless of the chemical process by which a wood pulp is produced, the mechanical methods of de-watering the washed fiber assume importance since the remaining water must be evaporated to enable the manufacturer to ship dry pulp. Ease of stock concentration depends upon fiber dimensions, the tenacity with which the fiber holds water, the temperature, and the magnitude of the pressure applied. In addition, there is the proper selection of an absorptive material against which the sheeted fiber mass is pressed. Here again the chemical engineer finds ample opportunity to ply his trade.

Considerable advance has been made in the design and operation of pulp driers, but more remains to be done to improve both the thermal economy and the operating costs. Steam heated contact rolls over which the pulp sheet travels at atmospheric pressure, similar installations encased in a sealed vacuum chamber, and hot air driers are used regularly. Pulp driers in which shreds instead of a continuous sheet are dried by hot air are also employed. Recovery of heat from effluent humid air is practiced. Yet overall efficiencies are not remarkable. Chemical engineers will find a better solution.

The manufacture of wood pulp is not a new industry; yet much remains to challenge the ingenuity of new and ambitious chemical engineers.

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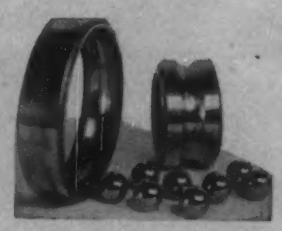

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MICROANALYSIS

IN ordinary chemical analysis, where material is plentiful, the work is done on a scale most suitable for obtaining the results sought. Samples are relatively abundant; they may be used prodigally.

Not always, however, is the material for test so plentiful. The General Electric Research Laboratory at Schenectady, N. Y., handles the exceptions with its facilities for "microchemistry," in which the amount of test material available controls both the scale of operations and the strategy of attack. Microanalyst Charles Van Brunt, Harvard, '92, of the laboratory staff is prepared to test material whose limit in smallness is set only by the refinements of manipulation attainable under the microscope with the aid of a "micromanipulator."

Seldom does Van Brunt attempt to identify or classify materials in solution volumes less than a cubic millimeter (about the size of a pinhead). But to analyze an ordinary drop, as delivered from a medicine dropper, is comparatively coarse work for him—near the upper limit of the true microchemical range.

FROZEN LIGHT

THE "late" Baron Munchausen was accredited (by himself) with incredible feats among which was freezing the ring of a bell. Recently, however, General Electric Research Laboratory scientists at Schenectady, N. Y., outdid the Baron by freezing light.

In producing this frozen light, G-E scientists submerged fluorescent plates in a large thermos bottle of liquid air with a temperature of 320 degrees below zero. The bottle and the plates were then bombarded by x-rays, exciting the atoms of fluorescent material on the plates literally freezing them stiff. When the plates were removed and allowed to warm up, they glowed with all the colors of the rainbow.

A "bottle" of frozen light was sent to East Orange, N. J., where it was unveiled in connection with the ceremonies marking the premiere of the motion picture, "Edison, The Man."

RADIO TURKISH BATH

RATS and moisture seem to be the two chief enemies of radio sets in the tropics. A letter from the Belgian Congo testifies to the rats; the evidence for the humidity is already ample. Except for recommending traps, there is little the General Electric Company can do about the rats, but the study of humidity is right up its alley since G-E engineers at Bridgeport, Conn., have built a humidity chamber capable of reproducing the weather conditions of the tropics.

Lamps under water tanks provide humidity by vaporization, and generate enough heat to maintain a temperature of about 100 F. Humidity and temperature are controlled by time clocks outside the sealed chamber, while uniform weather conditions are maintained within the chamber by circulating fans.

Radio receivers placed in this room are continuously subjected to conditions far more severe than those of the tropics until failures occur in the sets. In this way, young engineering college graduates enrolled in the G-E Test Course gather data which contribute to the improvement of radio, not only in the tropics, but everywhere that radios are used.

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